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[Title of the Invention] HEAD DRIVE APPARATUS AND METHOD FOR INKJET PRINTER

[Claims]

[Claim 1] In a head drive apparatus, for an inkjet printer, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus for an inkjet printer is characterized by comprising

a bias power supply circuit for applying a predetermined bias voltage to a ground-side electrode of each piezoelectric element.

[Claim 2] A head drive apparatus for an inkjet printer according to claim 1, characterized in that the bias voltage outputted from said bias power supply circuit is adjustable.

[Claim 3] A head drive apparatus for an inkjet printer according to any one of claims 1 and 2, characterized in that said bias power supply circuit is a logic power supply circuit.

[Claim 4] An inkjet printer characterized by having the head drive apparatus according to any one of claims 1 to 3.

[Claim 5] In a head drive method, for an inkjet printer, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive method for an inkjet printer is

characterized in that

a bias power supply circuit applies a predetermined bias voltage to a ground-side electrode of each piezoelectric element.

[Claim 6] A head drive method for an inkjet printer according to claim 5, characterized in that the bias voltage outputted from said bias power supply circuit is adjustable.

[Claim 7] A head drive method for an inkjet printer according to any one of claims 5 and 6, characterized in that said bias power supply circuit is a logic power supply circuit.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a head drive technique, for an inkjet printer, such that the ground side of piezoelectric elements provided to correspond to nozzles for ejecting ink droplets is held at a higher potential than the ground, in a head of the inkjet printer.

[0002]

[Prior Art]

Conventionally, an inkjet color printer of the type in which inks of several colors are ejected from a printhead has prevailed as an output apparatus of a computer and has been widely used to print an image processed by the computer or the like in multiple colors and tones.

[0003]

For example, an inkjet printer using a piezoelectric element as a drive element for ejecting ink is configured as follows. Plural piezoelectric elements

provided to correspond to plural nozzles of a printhead are selectively driven. Thereby, ink droplets are ejected through the nozzles based on the dynamic pressure of the individual piezoelectric elements and adhered to print paper. Thereby, dots are formed on the print paper to perform printing.

[0004]

Here, each piezoelectric element, provided to correspond to each nozzle for ejecting an ink droplet, is driven based on a drive signal supplied from a driver IC mounted in a printer body or the printhead, thus ejecting an ink droplet.

[0005]

In the meantime, in such a piezoelectric element, during non-drive (i.e. when printing is not performed), electric charge stored by charging is discharged and the voltage of the piezoelectric element is lowered, thereby affecting the ink ejection in some cases.

[0006]

Consequently, Japanese Patent No. 3097155 obtained by the present inventor discloses a head drive apparatus and method configured such that a charge voltage is applied to the piezoelectric element with a different timing from the drive timing, thus maintaining the charge voltage.

[0007]

[Problems that the Invention is to Solve]

However, in such head drive of an inkjet printer, the drive signal applied to each piezoelectric element is configured, for example, such as to be set to a high voltage during non-drive and have the voltage lowered during drive. In this case, the voltage applied to the piezoelectric element becomes

comparatively high. Therefore, a voltage drop due to the aforesaid discharging is also large, so that a power loss is large.

[0008]

When an increase in density of print dots is intended to be realized for an improvement in print quality, the gap between the electrodes of the piezoelectric elements adjacent to each other is narrowed. However, in case where the driven piezoelectric element and the non-driven piezoelectric element are adjacent to each other, when the voltage between the electrodes of these piezoelectric elements rises, in some cases, discharge occurs between the electrodes of these piezoelectric elements.

[0009]

Furthermore, each piezoelectric element is reduced in size due to the increase in density and thus reduced in withstanding pressure. Therefore, when the increase in density further proceeds, the maximum voltage of the drive signal exceeds the withstanding pressure of the piezoelectric element. Thus, there is the possibility that the piezoelectric element will not operate normally. Consequently, insulating such as filling of an insulation material will be needed between the electrodes of the piezoelectric elements.

[0010]

On the contrary, there is also a head drive method such that the ground side of each piezoelectric element is held at the intermediate potential of the drive signal. According to such a head drive method, it is possible to prevent the discharge between the electrodes of the piezoelectric elements that occurs upon the aforesaid increase in density. However, in correspondence to variation in the drive signal, the voltage need be varied,

and charging and discharging need be switched, so that a bi-directional variable power supply will be needed.

[0011]

Consequently, an object of the invention is to provide a head drive apparatus and method, for an inkjet printer, configured such that a voltage applied between the electrodes of each piezoelectric element is lowered with a simple configuration.

[0012]

[Means for Solving the Problems]

To solve the aforesaid problems, in the invention, a bias voltage from a bias power supply circuit is applied to a ground-side electrode of each piezoelectric element, thus holding the ground side of each piezoelectric element at a higher potential than the ground.

[0013]

That is, in the head drive apparatus for an inkjet printer according to claim 1, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus for an inkjet printer is characterized by comprising a bias power supply circuit for applying a predetermined bias voltage to a ground-side electrode of each piezoelectric element.

[0014]

Besides, in the head drive method for an inkjet printer according to claim 5, in which a piezoelectric element provided to correspond to each of

plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive method for an inkjet printer is characterized in that a bias power supply circuit applies a predetermined bias voltage to a ground-side electrode of each piezoelectric element.

[0015]

According to this configuration, the bias voltage is applied directly to the ground-side electrode of each piezoelectric element from the bias power supply circuit. Thereby, the ground side of the piezoelectric element is held at the bias voltage. Accordingly, the voltage applied between both electrodes of each piezoelectric element becomes comparatively low. Thereby, power consumption is reduced, and a voltage drop due to natural discharge of the piezoelectric element is small, so that a power loss is reduced.

[0016]

Besides, the voltage applied to the piezoelectric element becomes comparatively low. Thereby, the occurrence of discharge due to the voltage difference between the driven piezoelectric element and the non-driven piezoelectric element is also reduced. At the same time, even if the piezoelectric element is reduced in size due to the increase in density and thus reduced in withstanding pressure, it is possible to accommodate such a reduction. Therefore, the head can be further highly densified without performing insulating between the electrodes of the piezoelectric elements.

[0017]

The head drive apparatus according to claim 2 is characterized in that

the bias voltage outputted from the aforesaid bias power supply circuit is adjustable.

[0018]

The head drive method according to claim 6 is characterized in that the bias voltage outputted from the aforesaid bias power supply circuit is adjustable.

[0019]

According to this configuration, by adjusting the bias power supply, the bias voltage can be adjusted in correspondence to the intermediate potential, of the drive signal applied to the piezoelectric element, which varies depending on different inkjet printers. Therefore, the voltage applied between both electrodes of each piezoelectric element can be set to a lower value.

[0020]

The head drive apparatus according to claim 3 is characterized in that the aforesaid bias power supply circuit is a logic power supply circuit.

[0021]

The head drive method according to claim 7 is characterized in that the aforesaid bias power supply circuit is a logic power supply circuit.

[0022]

According to this configuration, the bias power supply circuit is configured as the logic power supply circuit. Thereby, the bias power supply circuit can be configured with ease and at a low cost, with a simple configuration.

[0023]

[Mode for Carrying out the Invention]

Embodiments of the invention will be described with reference to the drawings. Additionally, since the embodiments to be described below are preferred embodiments of the invention, various technically preferable limitations are put thereon. However, the scope of the invention is not limited to these embodiments unless the following description specifically states any limitation on the invention.

[0024]

Fig. 1 is a functional block diagram showing the whole configuration of an inkjet printer using the head drive apparatus of the invention. In Fig. 1, the inkjet printer of this embodiment comprises a printer body 2, a carriage mechanism 12, a paper feed mechanism 11, and a printhead 10. The paper feed mechanism 11, comprising a paper feed motor (not shown) and a paper feed roller (not shown), sequentially feeds a recording medium (not shown) such as print paper, thus performing a sub-scan. The carriage mechanism 12, comprising a carriage (not shown) mounting the printhead 10 and a carriage motor (not shown) driving this carriage via a timing belt (not shown), causes the printhead 10 to perform a main scan.

[0025]

The printer body 2 comprises an interface 3 for receiving print data including multi-value hierarchical information or like data from a host computer (not shown) or the like, a RAM 4 for storing various data such as the print data including multi-value hierarchical information, a ROM 5 storing a routine or the like for performing various data processes, a control section 6 comprising a CPU, an oscillating circuit 7, and an interface 9 for assuming the function of transmitting print data SI developed into dot pattern data to the printhead 10 or

like function.

[0026]

Here, the printhead 10 is circuit-connected to the printer body 2 via a not-shown flexible flat cable. As shown in Fig. 1, in the inkjet printer of this embodiment, the printer body 2 has therein a drive waveform generating circuit 80, a current amplifying circuit 113 connected to this drive waveform generating circuit 80, and a bias power supply circuit 120 connected to this current amplifying circuit 113. Functions etc. of these drive waveform generating circuit 80, current amplifying circuit 113, and bias power supply circuit 120 will be described later.

[0027]

The print data including multi-value hierarchical information sent from the host computer or the like is held in a receive buffer 4A inside the printer via the interface 3. The record data held in the receive buffer 4A is subjected to command analysis, and the control section 6 performs the process of adding a print position, a kind of modification, a size, a font address or the like of each character. Next, the control section 6 causes an output buffer 4C to develop and store the analyzed data as printing image data. Additionally, the RAM 4 is also provided with a work memory (work area) 4B for temporarily storing various work data or the like.

[0028]

Once printing image data equivalent to one scan of the printhead 10 is obtained, this printing image data is serially transferred to the printhead 10 via the interface 9. The printhead 10 has a large number of, 96 for example, nozzle orifices formed in a sub-scan direction and ejects an ink droplet through

each nozzle orifice with a predetermined timing. This printhead 10 comprises a head drive circuit including a shift register 13, a latch circuit 14, a level shifter 15, and plural analog switches 114. In synchronism with a clock signal (CLK) from the oscillating circuit 7,the print data developed into the printing image data on the printer body 2 side is serially transferred from the interface 9 to the shift register 13. This serially transferred print data (SI/print data) is once latched by the latch circuit 14. The level shifter 15, which is a voltage amplifier, boosts the voltage of the latched print data to a voltage capable of driving each analog switch 114a, for example, to a predetermined voltage of about several tens of volts. The print data SI voltage-boosted to the predetermined voltage is applied to the analog switches 114a.

[0029]

As shown in Fig. 1, the current of a drive waveform signal generated by the drive waveform generating circuit (head driver IC) 80 is amplified and outputted to the printhead 10 mounted on the carriage. Plural piezoelectric elements 111 and a head drive circuit 18 are formed on this printhead 10 side. The plural piezoelectric elements 111 pressurizes ink in pressure generating chambers to thereby eject ink droplets through the nozzle orifices. The head drive circuit 18 selects one to be driven among the plural piezoelectric elements 111 via the analog switches 114a or the like based on the print data SI. This head drive circuit 18 applies a drive signal COM to the piezoelectric element 111 whose analog switch 114a is turned on. Resultantly, the aforesaid piezoelectric element 111 pressurizes ink in the corresponding pressure generating chamber to eject the ink as ink droplets through the nozzle orifices.

[0030]

As shown in Fig. 2, the drive waveform generating circuit 80 comprises a memory 81 for storing drive waveform data applied by the control section 6 or the like in the printer body 2, a first latch 82 for temporarily holding the drive waveform data read from the memory 81, an adder 83 for adding the output of the first latch 82 and the output of a second latch 84 to be described later, the second latch 84, a D/A converter 86 for converting the output of the second latch 84 into analog data, and a voltage amplifying circuit 88 for amplifying the voltage of the converted analog signal to the voltage of the drive signal. Here, the memory 81 stores a predetermined parameter for determining the waveform of the drive signal. As described later, the waveform of the drive signal COM is predetermined by the predetermined parameter received from the aforesaid control section 6 or the like. Furthermore, the current of the drive waveform signal voltage-amplified by the voltage amplifying circuit 88 is amplified to such an extent that the aforesaid current amplifying circuit 113 can drive the analog switches 114a.

[0031]

As shown in Fig. 1, the output side of the current amplifying circuit 113 is connected to the plural analog switches 114a of the head drive circuit 18, and each analog switche 114a is connected to the corresponding piezoelectric element 111. And, formed on the ejecting face of the printhead are plural nozzles (for example, 96 nozzles per row) provided in position, for example, in three rows corresponding to three colors of CMY (in this example, K [black] is [composite black] formed from a composition of the three colors of CMY). The piezoelectric elements 111 provided to correspond to the plural nozzles are vibrated to pressurize ink in the pressure generating chambers, thereby

ejecting ink droplets through the plural nozzles.

[0032]

Fig. 3 shows the configuration of an embodiment of the head drive apparatus according to the invention. In Fig. 3, a head drive apparatus 100 comprises: the piezoelectric element 111 provided to correspond to each of the plural nozzles in the printhead 10 of the inkjet printer; the plural analog switches 114a each provided to correspond to the individual piezoelectric element 111; the aforesaid drive waveform generating circuit 80; provided in the printer body 2 in this embodiment, for supplying the drive signal to one-side electrode 111a of each piezoelectric element 111; and the bias power supply circuit 120 for applying a predetermined voltage to the current amplifying circuit 113 and the other, ground-side electrode 111b of each piezoelectric element 111.

[0033]

The piezoelectric element 111, which is a piezo-element for example, is configured to be displaced by a voltage applied between both electrodes 11a and 11b. And, the piezoelectric element 111 is always charged in the vicinity of an intermediate potential Vc. When discharged based on the drive signal COM outputted from the drive waveform generating circuit 80 via the current amplifying circuit 113, the piezoelectric element 111 pressurizes ink in the corresponding nozzle, thereby ejecting an ink droplet through this nozzle.

[0034]

The drive waveform generating circuit 80 is configured as a driver IC. The current amplifying circuit 113 comprises two transistors: a first transistor 115 and a second transistor 116. The first transistor 115 has a collector

connected to a constant voltage power supply (for example, 42 V), a base connected to the output of the drive waveform generating circuit 80, and an emitter connected to the input side of each analog switch 114a. Thereby, electrical conduction is established based on a signal from the drive waveform generating circuit 80, thus supplying a constant voltage to the piezoelectric element 111 via each analog switch 114a.

[0035]

Besides, the second transistor 116 has an emitter connected to the input side of each analog switch 114a, a base connected to the output of the drive waveform generating circuit 80, and a collector connected to ground. Thereby, electrical conduction is established based on a signal from the drive waveform generating circuit 80, thus discharging the piezoelectric element 111 via each analog switch 114a.

[0036]

Upon receipt of a control signal (print data SI), each analog switch 114a is turned on with the drive timing of the corresponding piezoelectric element 111, thus outputting the drive signal COM to the piezoelectric element 111. That is, the plural analog switches 114a are each configured as a so-called transmission gate 114 for turning on/off each piezoelectric element 111.

[0037]

The bias power supply circuit 120 is configured to apply a predetermined voltage to the other, ground-side common electrode 111b of the piezoelectric element 111. The predetermined voltage is a predetermined bias voltage Vb equal to or lower than the intermediate potential Vc based on the

drive signal COM of the piezoelectric 111. Here, the bias power supply circuit 120 specifically comprises a logic power supply circuit having an output voltage of 5 V for example so as to be able to adjust the bias voltage Vb to a desired voltage.

[0038]

The head drive apparatus 100 according to this embodiment is configured as aforesaid and operates as follows based on the head drive method according to the invention. The piezoelectric element 111 driven during printing will first be described. At the time of print start (START) of the inkjet printer, as shown in Fig. 4C, a charge signal NCHG is inverted to an L level for a time period of 100 μs for example. Thereby, the potential of the drive signal COM generated by the drive waveform generating circuit 80 is raised to the intermediate potential Vc, as shown in Fig. 4A.

[0039]

Thereby, the drive signal COM causes a current to flow from the first transistor 115 via each analog switch 114a to the one-side electrode 111a of each piezoelectric element 111, thus charging the one-side electrode 111a of the piezoelectric element 111. Thereby, the potential the one-side electrode 111a of the piezoelectric element 111 is raised to the intermediate potential Vc, as shown in solid line in Fig. 4B.

[0040]

At this time, the bias power supply circuit 120 applies the bias voltage Vb to the other, ground-side common electrode 111b of each piezoelectric element 111. Thereby, the potential of the other, ground-side common electrode 111b is held at the predetermined voltage Vb, as shown in dotted line

in Fig. 4B.

[0041]

Additionally, the aforesaid intermediate voltage Vc is set to a ratio α of, for example, 0.5 times the maximum voltage Vh of the drive signal COM. ($Vc=\alpha \cdot Vh$)

During printing, based on variation in the drive signal COM, the one-side electrode of each piezoelectric element 111 is charged via the first transistor 115 of the current amplifying current 113 and discharged via the second transistor 116 of the current amplifying circuit 113. Thereby, the piezoelectric element 111 operates based on the drive signal COM, thus ejecting an ink droplet.

[0042]

Here, as shown by reference character X in Fig. 4B, the voltage of the piezoelectric element 111 drops halfway due to self-discharge, so that the potential of the one-side electrode 111a of the piezoelectric element 111 becomes lower than the intermediate potential Vc. To prevent such a phenomenon, as shown by reference character Y in Fig. 4C, the charge signal NCHG generates L level pulses at regular cycles of the drive signal COM, i.e., with a timing such that there appears no variation in the drive signal COM.

[0043]

Thereby, based on the drive signal COM, the one-side electrode 111a of the piezoelectric element 111 is charged via the first transistor 115 of the current amplifying circuit 113. Thus, the potential of the one-side electrode 111a of even the non-driven piezoelectric element 111 is held at the intermediate potential Vc.

[0044]

On the contrary, the bias power supply circuit 120 applies the bias voltage Vb to the other, ground-side common electrode 111b of each piezoelectric element 111. Thereby, the potential of the other, ground-side common electrode 111b of the piezoelectric element 111 is held at this voltage Vb. Accordingly, the potential difference between both electrodes 111a and 111b of each piezoelectric element 111 becomes (Vc-Vb).

[0045]

Additionally, if the bias voltage Vb of the bias power supply circuit 120 is adjusted to become equal to the intermediate potential Vc, the potential difference between both electrodes 111a and 111b of each piezoelectric element 111 becomes zero.

[0046]

Furthermore, at the time of print end (END), as shown in Fig. 4A, the drive signal COM from the drive waveform generating circuit 80 is discharged from the one-side electrode 111a of the piezoelectric element 111 via the second transistor 116 of the current amplifying circuit 113. Thereby, the potential of the drive signal COM is lowered to a potential of zero. On the contrary, the one-side electrode 111a of the non-driven piezoelectric element 111 is always charged to and held at the intermediate potential by the drive signal COM from the drive waveform generating circuit 80.

[0047]

Thus, the potential of the ground-side electrode 111b of the piezoelectric element 111 is held at the constant voltage Vb by the bias voltage Vb from the bias power supply circuit 120. Therefore, the potential difference

between both electrodes 111a and 111b of the piezoelectric element 111 is held small. Besides, when the driven piezoelectric element and the non-driven piezoelectric element are adjacent to each other, the potential difference between the one-side electrodes 111a of these piezoelectric elements is also held small.

[0048]

Accordingly, power consumption of the piezoelectric element 111 is reduced, and the voltage drop due to self-discharge of the piezoelectric element 111 is small, thus reducing a power loss.

[0049]

Besides, the potential difference between the driven piezoelectric element 111 and the non-driven piezoelectric element 111 becomes small. Therefore, even when such piezoelectric elements are adjacent to each other, the generation of discharge between the piezoelectric elements is reduced. Besides, even when the withstanding pressure of the individual piezoelectric elements 111 is reduced due to an increase in density, there is no need to perform insulating between the piezoelectric elements 111. Therefore, the increase in density of the head can be easily realized.

[0050]

In the aforesaid embodiment, the piezoelectric element 111 uses a piezo-element for example but is not limited thereto. Alternatively, another piezoelectric element such for example as an electrostriction element or a magneto-striction element may be used.

[0051]

Besides, in the aforesaid embodiment, the bias power supply circuit

120 comprises the logic power supply circuit but is not limited thereto. Alternatively, a power supply circuit having another configuration can also be used if configured such as to be able to output the predetermined voltage.

[0052]

[Advantage of the Invention]

As aforesaid, according to the invention, the bias voltage is applied directly to the ground-side electrode of each piezoelectric element from the bias power supply circuit. Thereby, the ground-side electrode of each piezoelectric element is held at the predetermined voltage. Accordingly, the voltage applied between both electrodes of each piezoelectric element becomes comparatively low. Thus, even when the piezoelectric element is reduced in size due to the increase in density and thus reduced in withstanding pressure, it is possible to accommodate such a reduction. Therefore, the head can be more highly densified without performing insulating between the electrodes of the piezoelectric elements.

[Brief Description of the Drawings]

[Fig. 1]

A functional block diagram representing the whole configuration of an inkjet printer using a head drive apparatus of the invention;

[Fig. 2]

A functional block diagram representing the internal configuration of a drive waveform generating circuit of the inkjet printer shown in Fig. 1;

[Fig. 3]

A block diagram showing the configuration of an embodiment of the head drive apparatus according to the invention; and

[Fig. 4]

A timing diagram showing variations in (A) a drive signal, (B) the voltages of both electrodes of a piezoelectric element, and (C) a charge signal, in the head drive apparatus of Fig. 3.

[Description of the Reference Numerals and Signs]

100: Head drive apparatus

111: Piezoelectric element

111a: One-side electrode

111b: Ground-side electrode

80: Drive waveform generating circuit

113: Current amplifying circuit

114: Transmission gate

114a: Analog switch

115: First transistor

116: Second transistor

120: Bias power supply circuit

[Designation of Document] ABSTRACT

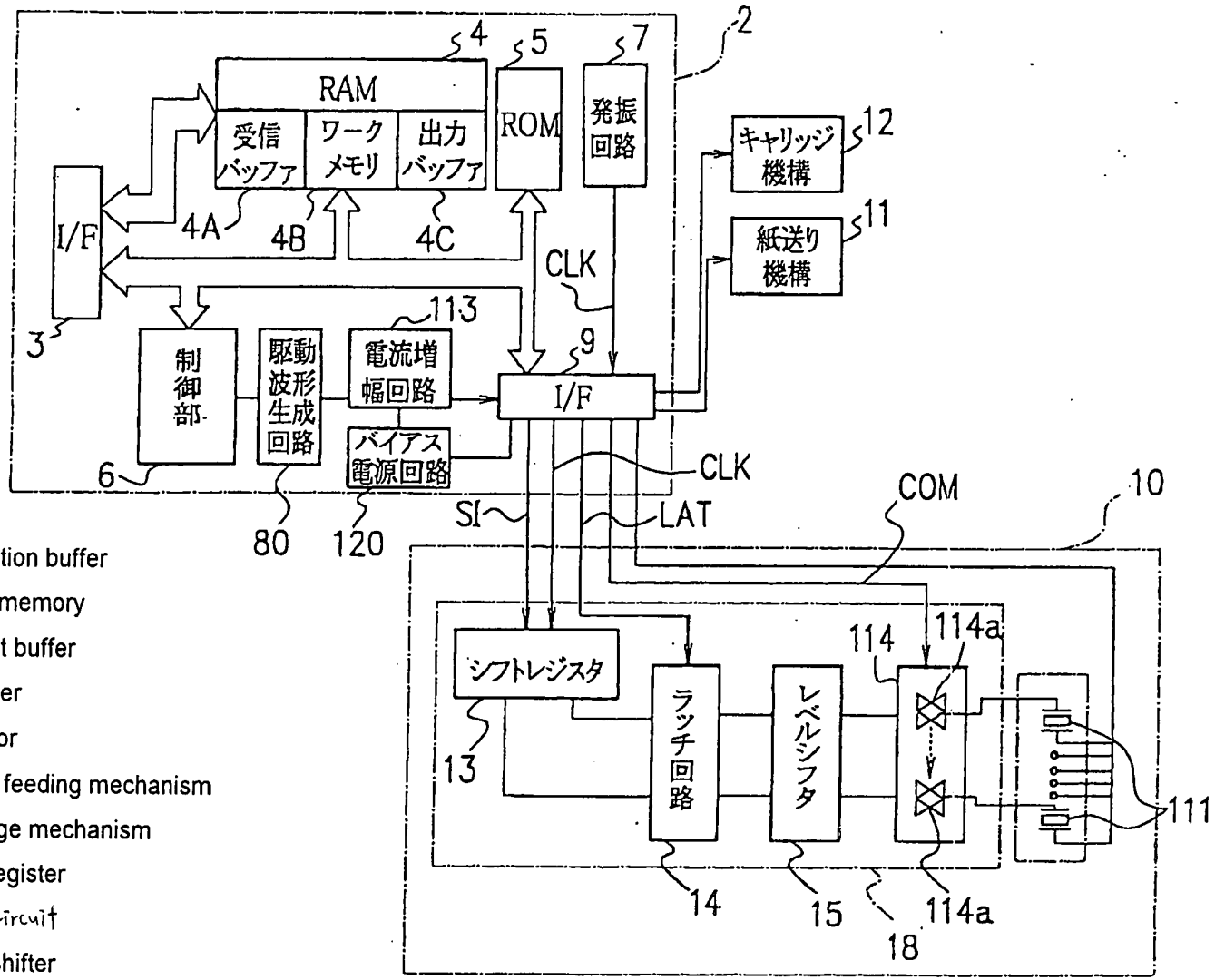
[Abstract]

[Problem] An object of the invention is to provide a head drive apparatus and method, for an inkjet printer, configured such that a voltage applied between the electrodes of each piezoelectric element is reduced with a simple configuration.

[Means for Resolution] In a head drive apparatus 10, for an inkjet printer, in which a piezoelectric element 11 provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal COM from a head drive circuit 12, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus 10 is configured to comprise a bias power supply circuit 20 for applying a predetermined bias voltage to a ground-side electrode 11b of each piezoelectric element.

[Selected Drawing] Fig. 3

Fig. 1



4A: reception buffer

4B: work memory

4C: output buffer

6: controller

7: oscillator

11: paper feeding mechanism

12: carriage mechanism

13: shift register

14: latch circuit

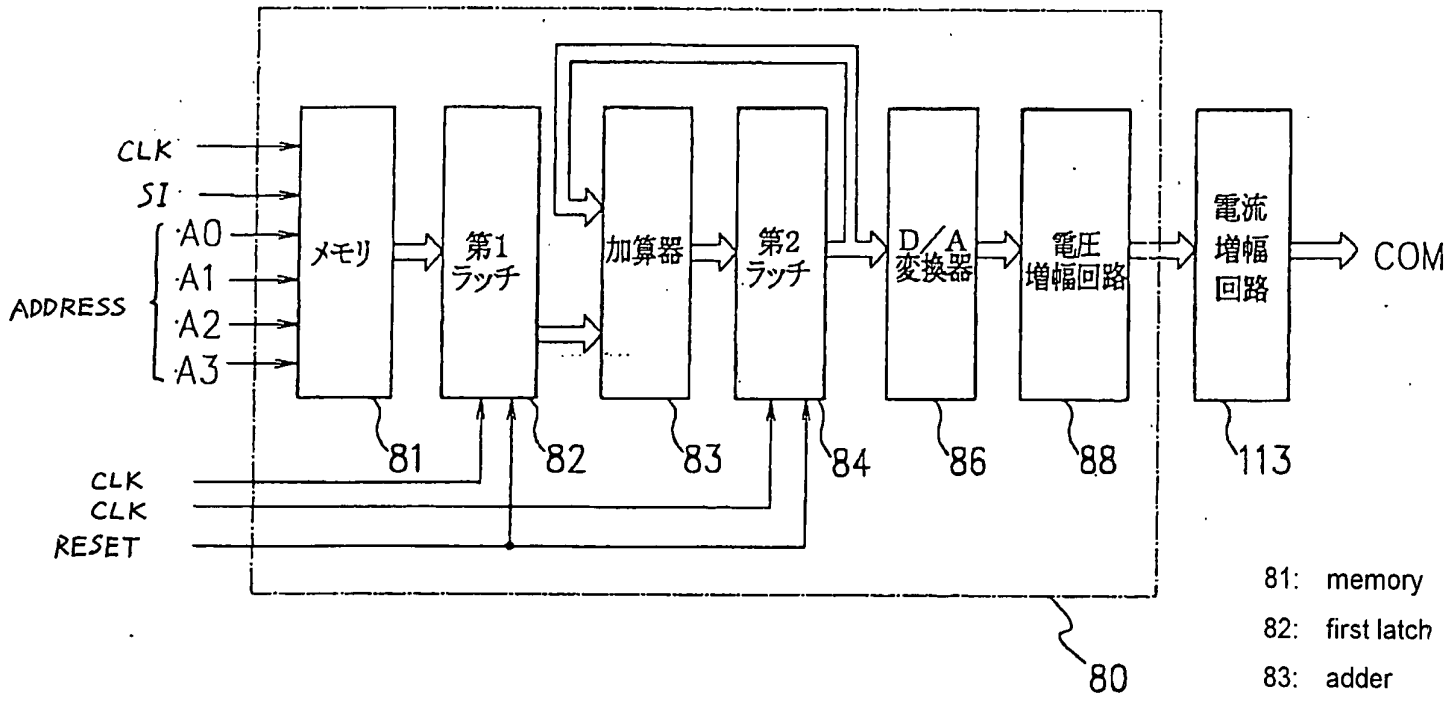
15: level shifter

80: drive waveform generating circuit

113: current amplifier circuit

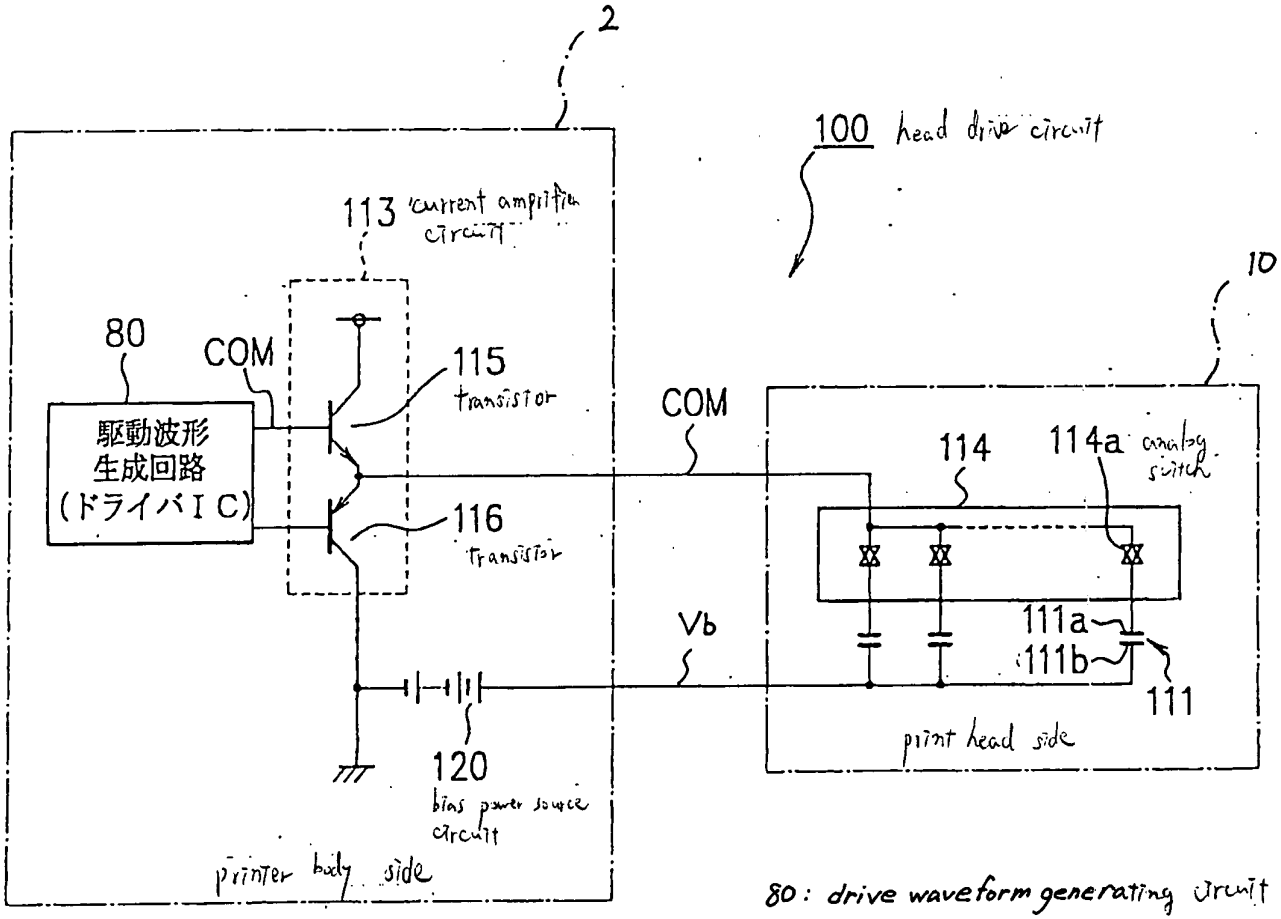
120: bias power source circuit

Fig. 2



81: memory
82: first latch
83: adder
84: second latch
86: D/A converter
88: voltage amplifier circuit
113: current amplifier circuit

Fig. 3



80 : drive waveform generating circuit (driver IC)

Fig.4